CIRCUIT DESCRIPTION

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# ELECTRONIC SWITCHING SYSTEMS

## NO. 3

## MULTIFREQUENCY TRANSMITTER CIRCUIT

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## SECTION I - GENERAL DESCRIPTION

### 1. PURPOSE OF CIRCUIT

1.01 This circuit generates voice-frequency signals in the multifrequency (MF) code. These signals are used to transmit the directory number of a customer to distant central offices over a trunk circuit. In addition this circuit checks the continuity of trunks and will observe battery-reversal start-pulsing signals from the MF receiver of a distance office.

### 2. GENERAL DESCRIPTION OF OPERATION

2.01 When a call is to terminate in a distant office, that office must be sent the called number so that it can complete the call. An MF Transmitter is the circuit that sends the called number in the form of tone signals to the distant office. After the calling customer has dialed the called number and the processor has determined that the call is to another office, the processor locates an idle MF transmitter and connects it to the appropriate trunk circuit via a network path through a bypassed junctor. The trunk circuit will then send a seizure (start) signal to the distant office. The distant office will connect an idle MF receiver to the trunk and the MF transmitter will detect the connection with the continuity scan point. When the distant office is ready to receive digits, the MF receiver will send a wink (reverse battery) signal which will be detected by the polarity scan point. The processor will then operate the appropriate tone-select relays and the check relay to send the digits to the distant office. To verify that a digit was sent, the processor monitors the 2-of-6 check/digit-transmit scan point. After all digits have been sent, the processor idles the MF transmitter and releases it.

## SECTION II - DETAILED DESCRIPTION

### 1. GENERAL DESCRIPTION

1.01 MF signaling uses one group of six frequencies in the speech band (700, 900, 1100, 1300, 1500, and 1700 Hz). A valid MF signal consists of exactly two of these six frequencies. This signaling code is

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known as the 2-out-of-6 code. There are only 15 valid combinations, which can be used as digits or other signals.

1.02 When a call is to a distant office, the processor will locate and connect an idle MF transmitter to the appropriate trunk circuit via a network path through bypassed junctor. This connection will then cause the trunk circuit to send a seizure (start) signal to the distant office.

1.03 The processor will scan the continuity scan point of the MF transmitter to verify the trunk connection. The processor will now scan the polarity scan point of the MF transmitter for a start-pulsing signal from the MF receiver when the receiver is ready to receive digits.

1.04 When the MF transmitter receives a wink signal, the processor operates the appropriate two of the six tone-select relays to connect taps on two oscillator coils corresponding to the two frequencies that are to be sent as the MF signal. To verify that only two of the six tone-select relays are operated, a relay logic circuit (2-of-6 check) will operate a relay to allow the oscillators to be started when only two tone-select relays are operated. The processor will then operate the check relay to start the oscillators and send the MF signal. The processor will scan the 2-of-6 check/tone-transmit scan point to verify that the signal was sent. The processor will operate and release the six tone-select relays and the check relay to send the MF signals which correspond to the digits being sent.

## 2. SIGNALING CODE

2.01 The relationship between digits and other signals and the MF signaling frequencies in the 2-of-6 signaling code is shown in Table A.

TABLE A

MF 2-OUT-OF-6 CODE

| FREQUENCIES HZ | MEANING |
|---|---|
| 700, 900 | 1 |
| 700, 1100 | 2, CC |
| 700, 1300 | 4 |
| 700, 1500 | 7 |
| 700, 1700 | R,ST3P |
| 900, 1100 | 3 |
| 900, 1300 | 5 |
| 900, 1500 | 8 |
| 900, 1700 | STP |
| 1100, 1300 | 6 |
| 1100, 1500 | 9 |
| 1100, 1700 | KP, CR |
| 1300, 1500 | 0 |
| 1300, 1700 | ST2P |
| 1500, 1700 | ST |

Note: CC = Coin collect
CR = Coin return
R = Rering or ringback
KP = Keypulse
ST = Start [=1 + Coin for TSP(s)], [normal trunk start]
STP = Start [=0 + Coin for TSP(s)]
ST2P = Start [=1 + NonCoin for TSP(s)]
ST3P = Start [=0 + Noncoin for TSP(s)]

## 3. CONTROL OF CIRCUIT

3.01 The MF transmitter has eight state relays, S7(A) through CK(H), which are controlled by the distributor circuit. Relays S7(A) through S17(F) provide tone select, relay T(G) provides a test state, and relay CK(H) provides the tone start/stop control. The processor determines the state required and, via the peripheral decoder circuit, operates the appropriate relays.

3.02 Relays S7(A) through T(G), driven by -48 volts, each have a 1000-ohm resistor, in parallel with one break contact, in series with the coil to initially provide rapid operate. This arrangement also limits the maximum current through the distribute point when the relay is operated. A diode is connected from the distribute point to -48 volts to limit the transient voltage spike when the relay is released and to dissipate the relay-coil energy when released. The anode of the diode is connected to -48 volts.

3.03 Relay CK(H), driven by -48 volts, has a 4300-ohm resistor in series with the coil to limit the maximum current through the distribute point when the relay is operated. This relay is a mercury type designed for speed of operation without a relay contact around the resistor. A diode is connected from the distribute point to -48 volts to limit the transient voltage spike when the relay is released and to dissipate the relay-coil energy when released. The anode of the diode is connected to -48 volts.

3.04 The MF transmitter states are shown in Table B and Table C.

3.05 Relays will be referred to by their functional names and/or their distributor triplet name. Binary representation of relays is:

| CK | T | S17 | S15 | S13 | S11 | S9 | S7 |
|---|---|---|---|---|---|---|---|
| H | G | F | E | D | C | B | A |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

3.06 When the MF transmitter is in the idle state, all relays are released and no tone is sent. Operating any two of relays S7(A) through S17(F) and relay CK(H) will send an MF signal. Operating relays S17(F), T(G), and relays S7(A) through S15(E) will send the lower five frequencies from the lower-frequency oscillator. Operating relays S7(A), T(G), and relays S9(B) through S17(F) will send the higher five frequencies from the higher-frequency oscillator.

SEQUENCES OF OPERATION

3.07 Table D shows the typical state sequences of this circuit. See BSP 233-151-105 for more details.

3.08 The normal return to idle may be bypassed during extremely heavy traffic. The only requirement is that relay CK (H) must be idled before the circuit is released.

TABLE B

TRANSMITTER STATES - TONES

| S7(A) | S9(B) | S11(C) | S13(D) | S15(E) | S17(F) |
|---|---|---|---|---|---|
| 700Hz | 900Hz | 1100Hz | 1300Hz | 1500Hz | 1700Hz |

TABLE C

TRANSMITTER STATES - CONTROL

| RELAYS | | | | STATE |
|---|---|---|---|---|
| T (G) | CK (H) | S7 | S17 | |
| 0 | 0 | 0 | 0 | Idle |
| 0 | 1 | 0 | 0 | MF Tone out |
| 1 | 0 | 0 | 1 | Test lower freq osc |
| 1 | 1 | 1 | 0 | Test higher freq osc |

4. CIRCUIT OPERATION

LOOP TRUNKS

4.01 After an MF transmitter is connected to a trunk circuit, the processor will monitor the MF continuity scan point (SC0) for continuity between the MF transmitter and the trunk circuit. If continuity is not satisfied after a timed interval, the processor will connect the MF transmitter to a different trunk and/or connect a different MF transmitter to the trunk.

4.02 After SC0 operates, the processor will monitor the MF polarity scan point (SC1) for a wink (start-pulsing reverse-battery) signal from the MF receiver. SC1 with diodes CR1 and CR2 will operate when tip and ring are connected to -48 volts and ground respectively. While waiting for the wink signal, the processor will operate relay H(CK) to force the 2-of-6 check/tone-transmit scan point SC2 to operate so that it can be verified that it will operate if a 2-of-6-check failure or failure to tone transmit occurs.

4.03 When the wink signal is received, the distant office is ready to receive the MF signals. The processor will operate tone-select relays S11(C) and S17(F) to configure the tone oscillators to send the keypulse signal. Two LC tone oscillators (Q1 and Q2) generate the MF signals. The two tones are added together and amplified in mixer/amplifier circuit (Q3) and are transformer coupled to the tip and ring for a balanced signal for transmission. The MF signals are comprised of two different tone frequencies and the oscillators are designed (with appropriate relay contacts) such that Q1 will generate the lower frequency (700, 900, 1100, 1300, or 1500 Hz) and Q2 will generate the higher frequency (900, 1100, 1300, 1500, or 1700 Hz). A fixed capacitor (C1 and C2) is provided and it is switched via relay contacts to an appropriate tap on the inductor (L1 and L2) to vary the frequency of the LC oscillators. These relay contacts [relays S7(A) through S17(F)] are arranged such that the capacitor is kept charged through the break contacts to provide immediate oscillations when the circuit is operated.

4.04 A relay logic circuit (comprised of contacts of each of the six tone-select relays) checks that two out of the six relays are operated when a MF signal is to be sent. When only two select relay are operated, relay K operates, thus allowing the tone oscillators to operate. If relay K is not operated, the tone oscillators are inhibited from operating and scan point SC2 will operate, thus indicating 2-of-6 failure.

TABLE D

SEQUENCES OF OPERATION

| OPERATION | STATE SEQUENCE JHG FED CBA | MEANING |
|---|---|---|
| Send 1359 | 000 000 000 | Receive wink |
| | 000 100 100 | Set KP |
| | 010 100 100 | Send KP |
| | 000 000 011 | Stop KP, set 1 |
| | 010 000 011 | Send 1 |
| | 000 000 110 | Stop 1, set 3 |
| | 010 000 110 | Send |
| | 000 001 010 | Stop 3, set 5 |
| | 010 001 010 | Send 5 |
| | 000 010 100 | Stop 5, set 9 |
| | 010 010 100 | Send 9 |
| | 000 110 000 | Stop 9, set ST |
| | 010 110 000 | Send ST |
| | 000 000 000 | Stop ST, idle |
| Test low frequency (1100 Hz) | 000 000 000 | Idle |
| | 000 100 100 | Send 1100 |
| | 000 000 000 | Idle |
| Test high frequency (1500 Hz) | 000 000 000 | Idle |
| | 011 010 001 | Send 1500 |
| | 000 000 000 | Idle |

Note: Relay triplets ABC, and DEF may be operated either ABC and the DEF or DEF and then ABC. When a digit is stopped and then the relays are set for the next digit, triplet GHJ is set to zero first and then triplet ABC is set followed by triplet DEF. The time between triplet orders is approximately 150 USEC.

4.05 The processor will operate the CK(H) relay to send the MF signal. The processor will scan SC2 to verify that it is not operated, thus indicating that the signal has been sent.

4.06 If SC2 indicates a tone-transmit failure, the call is abandoned and a second attempt with a different MF transmitter is tried. After a timed interval, the processor will release the CK(H) relay to stop the MF signal and will reconfigure the tone-select relays S7(A) through S17(F) for the first digit to be sent. Relay H(CK) is a mercury-type relay chosen for speed of operation. This relay will operate and release much faster than the tone-select relays. This feature enables simultaneous control of the stopping of an MF signal and reconfiguring for the next signal in one order without false signaling. After a timed interval, the processor will operate the CK(H) relay to send the first digit. After a timed interval the processor releases relay CK(H) and reconfigures relays S7(A) through S17(F) for the next digit. This sequence is repeated until the last digit has been sent. The processor will then configure relays S7(A) through S17(F) to send the start signal and operate relay CK(H). After the timed interval, the processor releases relay CK(H), idles the path, idles the MF transmitter, and releases the circuit for the next call.

E&M TRUNKS

4.07 E&M trunk calls are processed like loop trunks, as previously explained, with one exception. The wink signal is received from the E&M trunk scan point and not from the MF transmitter polarity scan point.

TEST LOWER-FREQUENCY OSCILLATOR

4.08 When testing the MF transmitter, the ability to test each oscillator independently is necessary. To test that the lower-frequency oscillator can provide five tones, relays S17(F), T(G), and any one of relays S7(A) through S15(E) are operated. Relays S17(F) and T(G) provide a connection to start only the lower-frequency oscillator and provide one of the two relays necessary to operate the

2-of-6 check circuit to allow tone to be sent. Operating relays S7(A) through S15(E), one at a time, satisfies the 2-of-6 check and sends one tone corresponding to the relay connection on the oscillator.

TEST HIGHER-FREQUENCY OSCILLATOR

4.09 As with testing the lower-frequency oscillator, a similar test can be performed on the higher-frequency oscillator. Operating relays S7(A), T(G), and CK(H) provides the connection to start only the higher-frequency oscillator and provide one of the two relays necessary to operate the 2-of-6 check circuit to allow tone to be sent. Operating relays S9(B) through S17(F), one at a time, satisfies the 2-of-6 check and sends one tone corresponding to the relay connection on the oscillator.

## SECTION III - REFERENCE DATA

### 1. WORKING LIMITS

1.01 Maximum external loop resistance is 6000 ohms.

1.02 Minimum insulation resistance is 30,000 ohms.

1.03 Battery limits are -42.75 volts to -52.50 volts.

### 2. FUNCTIONAL DESIGNATIONS

2.01 Associated Scanner Ferrods

| Designation | Meaning |
|---|---|
| SC0 | Continuity |
| SC1 | Polarity |
| SC2 | 2-of-6 Check/Tone-Transmit |

2.02 Circuit states

| Designation | Meaning |
|---|---|
| NU | Not Used |

2.03 Relays

| Designation | Meaning |
|---|---|
| A | Select 700 Hz (S7) |
| B | Select 900 Hz (S9) |
| C | Select 1100 Hz (S11) |
| D | Select 1300 Hz (S13) |
| E | Select 1500 Hz (S15) |
| F | Select 1700 Hz (S17) |
| G | Test (T) |
| H | Tone Transmit (CK) |

### 3. FUNCTIONS

3.01 Provides for monitoring the trunk loop for continuity (SC0) and polarity (wink signal) (SC1).

3.02 Provides for transmitting digits to a distant office in the form of MF signals (2-tone frequencies) and verifies that the signal was sent (SC2).

### 4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a keysheet, the connecting information thereon is to be followed.

(a) Master Scanner Circuit - SD-3H140-01.

(b) Distribute Point Circuit - SD-3H150-01.

(c) Junctor and Junctor Control Circuit - SD-3H200-01.

(d) Universal Trunk Circuit - SD-3H220-01.

### 5. MANUFACTURING TESTING REQUIREMENTS

Intermediate Requirements

5.01 Before circuit packs are inserted in the unit, it should be verified that the unit is wired in accordance with the schematic and wiring drawings to prevent damage to the circuit packs.

End Requirements

5.02 This circuit should be tested to verify that it is wired in accordance with the schematic and wiring drawings, that the requirements of the circuit requirements table are met, and that the circuit is capable of performing all functions stated in this circuit description.

### 6. ALARM INFORMATION

6.01 This circuit is fused individually with one fuse to the -48 volt signal supply and one fuse to the -48 volt talk supply. If either or both fuses blow, it will cause an FA relay, in the frame on which this circuit is mounted, to operate an alarm.

### 7. TAKING EQUIPMENT OUT OF SERVICE

7.01 Information on taking this circuit out of service can be found in IM-3H000 and OM-3H000.

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